

## PATENT COOPERATION TREATY

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## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

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in its capacity as elected Office

Date of mailing (day/month/year) 08 October 1999 (08.10.99)	
International application No. PCT/GB99/00488	Applicant's or agent's file reference 5265299
International filing date (day/month/year) 17 February 1999 (17.02.99)	Priority date (day/month/year) 17 February 1998 (17.02.98)
Applicant SEWELL, Roger, Fane	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:  
15 September 1999 (15.09.99)

☐ in a notice effecting later election filed with the International Bureau on:  
\_\_\_\_\_

2. The election ☒ was  
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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Authorized officer

S. Mafla

Telephone No.: (41-22) 338.83.38

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 5265299		<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB99/00488	International filing date (day/month/year) 17/02/1999	Priority date (day/month/year) 17/02/1998	
International Patent Classification (IPC) or national classification and IPC G06F9/44			
Applicant CAMBRIDGE CONSULTANTS LIMITED et al.			
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 6 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 8 sheets.</p>			
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li>I <input checked="" type="checkbox"/> Basis of the report</li> <li>II <input type="checkbox"/> Priority</li> <li>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li>IV <input type="checkbox"/> Lack of unity of invention</li> <li>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li>VI <input type="checkbox"/> Certain documents cited</li> <li>VII <input checked="" type="checkbox"/> Certain defects in the international application</li> <li>VIII <input checked="" type="checkbox"/> Certain observations on the international application</li> </ul>			
Date of submission of the demand  15/09/1999		Date of completion of this report  23.03.2000	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465		Authorized officer  Rees. D  Telephone No. +49 89 2399 2139 	

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/00488

## I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

### Description, pages:

1,2,4-35 as originally filed

3,3a as received on 21/02/2000 with letter of 17/02/2000

### Claims, No.:

1-13 as received on 21/02/2000 with letter of 17/02/2000

### Drawings, sheets:

1-7 as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:  
☐ the claims, Nos.:  
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/00488

## V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

### 1. Statement

Novelty (N)	Yes:	Claims	1-13
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-13
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-13
	No:	Claims	

### 2. Citations and explanations

**see separate sheet**

## VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

**see separate sheet**

## VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

**see separate sheet**

**Re Item V**

**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Reference is made to the following documents:

D1: US-A-5 347 541  
D2: GB-A-2 209 414  
D3: WO-A-92 03905  
D4: US-A-4 661 913

2.1 It is clear from the prior art in the International Search Report as a whole that it is well known to use Bayesian inference to deduce the probabilities of particular events having occurred from measurements relating to attributes of those events. In particular, D1 relates to the use of such Bayesian inference in the context of sequences of received signals, and shows that it is natural in such a case to use an iterative process to determine the probabilities of the various sequences of symbols which could have resulted in the particular signals (D1, Abstract, column 1, lines 28 to 30, column 3, lines 45 to 67, column 5, lines 27 to 51, column 7, line 51, to column 8, line 11).

2.2 D2 is also concerned with estimating probabilities of events from sequences of measurements by an iterative process of Bayesian inference (see page 4, line 1, to page 5, line 11, page 14, line 13, to page 14, line 5, page 24, line 19, to page 25, line 18. Moreover, it at least identifies the relevance of marginal probability density functions - see page 19, lines 7 to 12. Also from other documents, e.g. D3, page 4, lines 4 to 8, the value of calculating marginal distributions is clear.

2.3 However, no available prior art suggests choosing to use as a basis for the probability model a probability distribution function having the property that it is fully defined by its marginal distributions, as specified in the current independent claims.

2.4 With reference to the dependent claims, firstly data reduction by quantisation is commonplace. However, the specific use of "transformed log moments" is not

apparently disclosed in the prior art. Secondly, the use of Bayesian inference in the context of detecting particles in a fluid flow is known - see D4, Abstract and column 18, line 8, to column 19, line 2. The use of an iterative variant would appear to be obvious from D1.

**Re Item VII**

**Certain defects in the international application**

1. It is not clear from the introduction to the description what is the invention as claimed, and therefore it is also not clear what is the technical problem addressed by the invention and its solution, in violation of Rule 5.1(a)(iii) PCT.
2. The amended description page 3A contains typographical errors. On line 7, "note" should be "node". On line 8, "and each corresponds" should presumably be "and each arc corresponds" (see D3, page 3, line 28). On line 17, "clarify" should presumably be "identify".

**Re Item VIII**

**Certain observations on the international application**

1. The claimed subject-matter is not fully supported by the description, in violation of Article 6 PCT. It also violates Article 5 PCT in that the application does not disclose how to carry out the invention in the breadth claimed.
2. It is essential to the invention as described that the probability distributions used are Dirichlets or mixtures of Dirichlets. According to the description, a particular important feature of such distributions is that they are defined by their marginal distributions (e.g. page 17, line 18, to page 18, line 2). No other distributions are disclosed in the application as having this property. However, this property is clearly essential for the invention as claimed, since it is specified that the process of inference operates using prior marginal distributions and generates posterior marginal distributions. Hence it would be necessary, in order that the claimed subject-matter be fully supported by the description as required by Article 6 PCT, to specify in any independent claim that the prior probability distribution is approximated by a Dirichlet distribution or mixture of Dirichlets (cf. current

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/GB99/00488

dependent claims 5 and 13).

3. The current independent claims specify merely the required property that a probability distribution, to be usable, must have, viz. that it must be fully defined by its marginals. Thus this feature is specified functionally in the claim. But it is not such a feature that the skilled person could readily supply alternatives to the single embodiment of that feature disclosed in the description, viz. Dirichlets or mixtures of Dirichlets. Hence defining the feature by function leads to an unacceptably broad claim, in this case (see PCT Guidelines III 6.5). The claim is not fully supported, in violation of Article 6 PCT.
4. Equally, since the claim embraces embodiments which are by no means disclosed, i.e. embodiments which use some other distribution than a Dirichlet or mixture of Dirichlets, Article 5 PCT is not satisfied, since the skilled person is not in a position to carry out those embodiments of the invention without using inventiveness.

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size. Variations in light intensity caused by the passage of the particles relative to the light field are detected and the size of a particle can be calculated by plotting the mean peak signal of the sensor as a function of the normalised peak-to-trough variation in the output pulses generated by the passages of the particle through the light field. Such a system can be made in an extremely compact and relatively inexpensive manner but is not suitable for relatively large flow sizes where there are likely to be a substantial number of particles in the volume where the measurements are being made. Thus this system is not suited, for example, measuring the distribution of particles in the situation where it is required to provide measurements of smoke particles in a gas flow.

Thus the present invention is concerned with providing a solution to the above problems and in particular a solution to the problem of providing accurate measurements of multiple physical events which are not directly observable.

United States Patent Specification No US-A-5347541 discloses Bayesian blind equalizer for use in digital communication comprising a plurality of parallel processors. Each processor in turn generates an estimated signal and an updated metric in order to be able to decode digital data despite intersymbol interference.

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UK Patent Specification No GB-2209414-A discloses a navigation system using a recursive estimator employing Bayesian logic.

International Patent Specification No WO92/03905  
5 discloses a method and apparatus for optimally allocating resources and and discloses an iterative process utilising a probabilistic network in which each node corresponds to a variable and each corresponds to a constraint so that the topology of the network directly  
10 reflects the structure of the problem. The network is iterated until it reaches a stable state.

United States Patent Specification No US-A-4661913 discloses a flow apparatus through which unknown particles to be measured are passed, data generated by  
15 the passage of the particles stored, and this data is then compared with data detected from sample particles in order to clarify the unknown particles.

In order that the present invention may be more readily understood an embodiment thereof will now be  
20 described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a cross-section through an embodiment of a particle measurement system;

Figure 2 illustrates a sample reading;

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## CLAIMS:

1. Apparatus for obtaining a posterior probability distribution  $P(p|D)$  relating to an attribute or  
5 attributes  $\theta$  quantized into  $I$  values  $(\theta_1, \dots, \theta_I)$  of a succession of events each one of which is one of the types  $(E_1, E_2, \dots, E_I)$  in which the events generate measurable physical reactions, the posterior probability distribution  $P(p|D)$  being on a distribution  $P(\theta)$  of  $\theta$ ,  
10 where  $P(\theta)$  is represented by  $p = (p_1, p_2, \dots, p_I)$  where  $p_i = P(\theta_i)$ ; the apparatus comprising:

means for detecting the physical reactions generated by the events and generating measurements  $D = (D_1, D_2, \dots, D_j, \dots)$  in response to the detected reactions; and

15 inferential processing means for deriving values  $P(p_i = q_{i,k}|D)$  at points  $q_{i,k}$  of the marginal distributions  $P(p_i|D)$  of the probability distribution  $P(p|D)$  for the distribution of the attribute or attributes  $\theta$  of the events by carrying out a Bayesian inferential process  
20 utilising the values  $(D_1, D_2, \dots, D_j, \dots)$ , the marginal values  $P(p_i = q_{i,k})$  of a preset prior probability distribution  $P(p)$  which marginal values define the complete preset prior probability distribution, and a  
25 stored set of values  $P(D_j|E_i)$  representing a range of probability distributions for the occurrence of each of the observed measurements  $D$  from the events of each type

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of  $E$  occurring, the inferential process being an iterative process in which the values  $P(p_i = q_{i,k} | D_1, \dots, D_j)$  of the marginals  $P(p_i | D_1, \dots, D_j)$  after the  $j$ th event are generated from the values  $P(p_i = q_{i,k} | D_1, \dots, D_{j-1})$  of the marginals  $P(p_i | D_1, \dots, D_{j-1})$  prior to that event.

2. Apparatus according to claim 1, wherein the generating means are adapted to generate an analog signal and include analog-to-digital conversion means for converting the analog signal into a digital signal and means for compressing the data content of the digital, the output of said compression means being connected to said processing means.

3. Apparatus according to claim 2, wherein the compression means are adapted to compress the digital output of the ADC means to generate the value  $D$  by taking quantized transformed log moments.

4. Apparatus according to claim 3, wherein the compression means obtain the quantized transformed log moments by carrying out the steps set out as follows:

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$$\bar{y} = \frac{1}{M} \sum_{m=1}^M y_m$$

$$u_n = \frac{1}{M} \sum_{m=1}^M (y_m - \bar{y})^n$$

$$z_m = y_{m+1} - y_m$$

$$\bar{z} = \frac{1}{M-1} \sum_{m=1}^{M-1} z_m$$

$$u_n' = \frac{1}{M-1} \sum_{m=1}^{M-1} (z_m - \bar{z})^n$$

$$u = \begin{pmatrix} \log|u_2| \\ \log|u_3| \\ \log|u_4| \end{pmatrix}$$

$$v = Tu + t$$

5. Apparatus according to any preceding claim, wherein the preset prior probability distribution is of Dirichlet form or is a mixture of Dirichlets.

6. Apparatus according to claim 5, wherein the preset prior probability distribution is

$$P(p \mid \sum_i p_i = 1) = \frac{\Gamma(\sum_i \alpha_i)}{\prod_i \Gamma(\alpha_i)} \prod_i p_i^{\alpha_i - 1}$$

where all  $\alpha_i > 0$ .

7. Apparatus according to any one of the preceding claims, wherein the marginals are updated using an algorithm carrying out the equation

$$\log P(p_i \mid D) = \log P(p_i) + \log(1 - p_i) + f \left( \log \frac{p_i}{1 - p_i} - \log \frac{P(E_i)}{1 - P(E_i)} + \log \left( \frac{P(D_{i1} \mid E_i) P(E_i)}{\sum_{k=1}^K P(D_{ik} \mid E_k) P(E_k)} \right) \right) + K$$

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8. Apparatus according to any one of the preceding claims, wherein the generating means comprise a means defining a passage through which particles to be measured must pass, means for irradiating the particles, and means  
5 for detecting perturbations in the radiation caused by the particles to generate an analog signal.

9. Apparatus according to claim 8 wherein the means for irradiating the particles comprise a source of  
10 monochromatic light adapted to produce a structured light field in a measurement volume in said passage, particles in use passing transversely through the structured light field.

15 10. A method of obtaining a posterior probability distribution  $P(p|D)$  relating to an attribute or attributes  $\theta$  quantized into  $I$  values  $(\theta_1, \dots, \theta_I)$  of a succession of events each one of which is one of the types  $(E_1, E_2, \dots, E_I)$  in which the events generate  
20 measurable physical reactions, the posterior probability distribution  $P(p|D)$  being on a distribution  $P(\theta)$  of  $\theta$ , where  $P(\theta)$  is represented by  $p = (p_1, p_2, \dots, p_I)$  where  $p_i = P(\theta_i)$ ; the method comprising:

detecting the physical reactions generated by the  
25 events and generating measurements  $D=(D_1, D_2, \dots, D_j, \dots)$  in response to the detected reactions; and

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deriving values  $P(p_i = q_{i,k} | D)$  at points  $q_{i,k}$  of the marginal distributions  $P(p_i | D)$  of the probability distribution  $P(p | D)$  for the distribution of the attribute or attributes  $\theta$  of the events by carrying out a Bayesian

5 inferential process utilising the values  $(D_1, D_2, \dots, D_j, \dots)$ , the marginal values  $P(p_i = q_{i,k})$  of a preset prior probability distribution  $P(p)$  which marginal values define the complete preset prior probability distribution, and a stored set of values  $P(D_j | E_i)$

10 representing a range of probability distributions for the occurrence of each of the observed measurements  $D$  from the events of each type of  $E$  occurring, the inferential process being an iterative process in which the values  $P(p_i = q_{i,k} | D_1, \dots, D_j)$  of the marginals  $P(p_i | D_1, \dots, D_j)$

15 after the  $j$ th event are generated from the values  $P(p_i = q_{i,k} | D_1, \dots, D_{j-1})$  of the marginals  $P(p_i | D_1, \dots, D_{j-1})$  prior to that event.

11. A method according to claim 10, wherein an analog

20 signal is generated by the events being measured which signal is converted into a digital signal, and the digital signal is compressed prior to the inferential processing.

25 12. A method according to claim 11, wherein the digital signal is compressed by taking quantized transformed log

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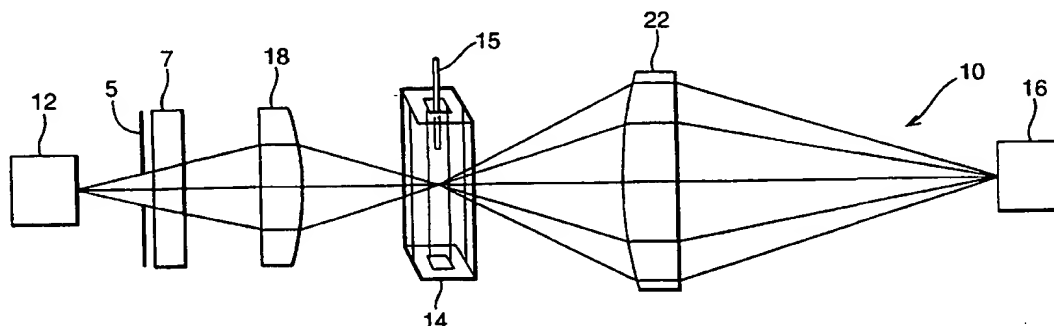
moments.

13. A method according to any one of claims 10 to 12,  
wherein the preset prior probability distribution is of  
5 Dirichlet form or is a mixture of Dirichlets.

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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>G06F 9/44, G01N 15/14</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 99/41662</b> <b>(43) International Publication Date:</b> 19 August 1999 (19.08.99)
<b>(21) International Application Number:</b> PCT/GB99/00488 <b>(22) International Filing Date:</b> 17 February 1999 (17.02.99)  <b>(30) Priority Data:</b> 9803368.1                      17 February 1998 (17.02.98)                      GB  <b>(71) Applicant (for all designated States except US):</b> CAMBRIDGE CONSULTANTS LIMITED [GB/GB]; Science Park, Milton Road, Cambridge CB4 4DW (GB).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> SEWELL, Roger, Fane [GB/GB]; 19 Champneys Walk, Newnham, Cambridge CB3 9AW (GB).  <b>(74) Agents:</b> BERESFORD, Keith, Denis, Lewis et al.; Beresford & Co., 2-5 Warwick Court, High Holborn, London WC1R 5DJ (GB).		<b>(81) Designated States:</b> US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

**(54) Title:** MEASUREMENT SYSTEM**(57) Abstract**

The invention concerns measurement apparatus for obtaining measurements relating to an attribute or attributes  $\theta$  of a succession of events in which an event generates a measurable physical reaction, the apparatus comprising generating means for generating a value  $D$  representing the physical reaction caused by an event, and inferential processing means for deriving the marginal distributions of a probability distribution for the attribute or attributes  $\theta$  of the events by carrying out a Bayesian inferential process utilising the value  $D$ , the marginal values of a prior probability distribution and a stored set of values representing a range of probability distributions for the occurrence of each of the events being measured, the inferential process being an iterative process in which the marginals posterior to one event are generated by updating the marginals prior to that event.



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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/00488

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G06F9/44 G01N15/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 347 541 A (ILTIS) 13 September 1994 see column 2, paragraph 2 see column 3, last paragraph see column 8, line 32 - column 9, line 10 ---	1,10
Y	GB 2 209 414 A (GEC-MARCONI) 10 May 1989 see abstract see page 4, line 1 - page 5, line 11 see page 14, line 13 - page 15, line 5 see page 19, line 7 - line 12 see page 24, line 19 - page 25, line 18 see figure 10 --- -/--	1,10

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

18 June 1999

Date of mailing of the international search report

25/06/1999

Name and mailing address of the ISA

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Thomas, R.M.

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 99/00488

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 97 41458 A (MIT) 6 November 1997</p> <p>see page 13, line 11 - line 15  see page 31, line 1 - page 32, line 10  see page 34, line 4 - line 8  see page 35, line 7 - line 21</p> <p>---</p>	1,2,10, 11
A	<p>WO 92 03905 A (VOLVO) 19 March 1992</p> <p>see page 3, line 2 - page 4, line 16  see page 8, line 1 - line 17  see page 10, line 11 - page 11, line 18</p> <p>---</p>	1,10
A P,A	<p>WO 95 22806 A (PHILIPS) 24 August 1995</p> <p>see page 6, line 32 - page 8, line 7  &amp; US 5 774 581 A (FASSNACHT) 30 June 1998  see column 4, line 20 - line 65</p> <p>---</p>	1,10
A	<p>US 4 661 913 A (WU) 28 April 1987</p> <p>see column 18, line 8 - column 19, line 2  see figure 9</p> <p>-----</p>	8

# INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/GB 99/00488

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5347541	A	13-09-1994	NONE	
GB 2209414	A	10-05-1989	DE 3636131 A	08-08-1991
			FR 2599874 A	11-12-1987
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			EP 0896678 A	17-02-1999
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			FR 2728090 A	14-06-1996
			EP 0694193 A	31-01-1996
			JP 8509313 T	01-10-1996
			US 5774581 A	30-06-1998
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			FR 2570192 A	14-03-1986
			JP 61071337 A	12-04-1986

## PCT COOPERATION TREATY

PCT

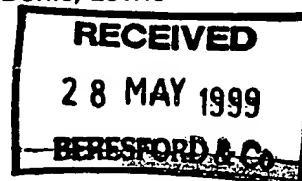
NOTIFICATION CONCERNING  
SUBMISSION OR TRANSMITTAL  
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

From the INTERNATIONAL BUREAU

To:

BERESFORD, Keith, Denis, Lewis  
Beresford & Co.  
2-5 Warwick Court  
High Holborn  
London WC1R 5DJ  
ROYAUME-UNI



Date of mailing (day/month/year) 17 May 1999 (17.05.99)	
Applicant's or agent's file reference 5265299	IMPORTANT NOTIFICATION
International application No. PCT/GB99/00488	International filing date (day/month/year) 17 February 1999 (17.02.99)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 17 February 1998 (17.02.98)
Applicant CAMBRIDGE CONSULTANTS LIMITED et al	

- The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
- This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.
- An asterisk(\*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
- The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
17 Febr 1998 (17.02.98)	9803368.1	GB	28 Apr 1999 (28.04.99)

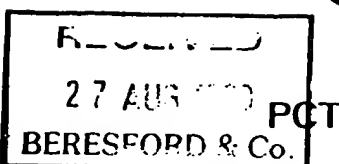
The International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Juan Cruz

Telephone No. (41-22) 338.83.38



From the INTERNATIONAL BUREAU

To:  
BERESFORD, Keith, Denis, Lewis  
Beresford & Co.  
2-5 Warwick Court  
High Holborn  
London WC1R 5DJ  
ROYAUME-UNI

**NOTICE INFORMING THE APPLICANT OF THE  
COMMUNICATION OF THE INTERNATIONAL  
APPLICATION TO THE DESIGNATED OFFICES.**

(PCT Rule 47.1(c), first sentence)

Date of mailing (day/month/year) 19 August 1999 (19.08.99)		
Applicant's or agent's file reference 5265299		<b>IMPORTANT NOTICE</b>
International application No. PCT/GB99/00488	International filing date (day/month/year) 17 February 1999 (17.02.99)	
Priority date (day/month/year) 17 February 1998 (17.02.98)		
Applicant CAMBRIDGE CONSULTANTS LIMITED et al		

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:  
**EP,US**

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:  
**None**

The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on 19 August 1999 (19.08.99) under No. WO 99/41662

**REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)**

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

**REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))**

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer  J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

Continuation of Form PCT/IB/308

**NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF  
THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES**

<b>Date of mailing (day/month/year)</b> 19 August 1999 (19.08.99)	<b>IMPORTANT NOTICE</b>
<b>Applicant's or agent's file reference</b> 5265299	<b>International application No.</b> PCT/GB99/00488
<p>The applicant is hereby notified that, at the time of establishment of this Notice, the time limit under Rule 46.1 for making amendments under Article 19 has not yet expired and the International Bureau had received neither such amendments nor a declaration that the applicant does not wish to make amendments.</p>	

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>5265299</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 99/ 00488</b>	International filing date (day/month/year) <b>17/02/1999</b>	(Earliest) Priority Date (day/month/year) <b>17/02/1998</b>
Applicant <b>CAMBRIDGE CONSULTANTS LIMITED et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

**1. Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1

☐ None of the figures.



## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/00488

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G06F9/44 G01N15/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 347 541 A (ILTIS) 13 September 1994 see column 2, paragraph 2 see column 3, last paragraph see column 8, line 32 - column 9, line 10 ---	1, 10
Y	GB 2 209 414 A (GEC-MARCONI) 10 May 1989 see abstract see page 4, line 1 - page 5, line 11 see page 14, line 13 - page 15, line 5 see page 19, line 7 - line 12 see page 24, line 19 - page 25, line 18 see figure 10 --- -/--	1, 10



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&amp;" document member of the same patent family

Date of the actual completion of the international search

18 June 1999

Date of mailing of the international search report

25/06/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
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Fax: (+31-70) 340-3016

Authorized officer

Thomas, R.M.

## INTERNATIONAL SEARCH REPORT

International Application No

GB 99/00488

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 41458 A (MIT) 6 November 1997  see page 13, line 11 - line 15 see page 31, line 1 - page 32, line 10 see page 34, line 4 - line 8 see page 35, line 7 - line 21 ---	1, 2, 10, 11
A	WO 92 03905 A (VOLVO) 19 March 1992 see page 3, line 2 - page 4, line 16 see page 8, line 1 - line 17 see page 10, line 11 - page 11, line 18 ---	1, 10
A P, A	WO 95 22806 A (PHILIPS) 24 August 1995 see page 6, line 32 - page 8, line 7 & US 5 774 581 A (FASSNACHT) 30 June 1998 see column 4, line 20 - line 65 ---	1, 10
A	US 4 661 913 A (WU) 28 April 1987 see column 18, line 8 - column 19, line 2 see figure 9 -----	8

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

GB 99/00488

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5347541	A	13-09-1994	NONE	
GB 2209414	A	10-05-1989	DE 3636131 A	08-08-1991
			FR 2599874 A	11-12-1987
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WO 9741458	A	06-11-1997	US 5844415 A	01-12-1998
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			JP 8509313 T	01-10-1996
			US 5774581 A	30-06-1998
US 4661913	A	28-04-1987	DE 3531969 A	20-03-1986
			FR 2570192 A	14-03-1986
			JP 61071337 A	12-04-1986

size. Variations in light intensity caused by the passage of the particles relative to the light field are detected and the size of a particle can be calculated by plotting the mean peak signal of the sensor as a function  
5 of the normalised peak-to-trough variation in the output pulses generated by the passages of the particle through the light field. Such a system can be made in an extremely compact and relatively inexpensive manner but is not suitable for relatively large flow sizes where  
10 there are likely to be a substantial number of particles in the volume where the measurements are being made. Thus this system is not suited, for example, measuring the distribution of particles in the situation where it is required to provide measurements of smoke particles  
15 in a gas flow.

Thus the present invention is concerned with providing a solution to the above problems and in particular a solution to the problem of providing accurate measurements of multiple physical events which  
20 are not directly observable.

In order that the present invention may be more readily understood an embodiment thereof will now be described by way of example and with reference to the accompanying drawings, in which:

25 Figure 1 is a cross-section through an embodiment of a particle measurement system;

Figure 2 illustrates a sample reading;

## CLAIMS:

1. Apparatus for obtaining measurements relating to an  
5 attribute or attributes  $\theta$  of a succession of events in  
which an event generates a measurable physical reaction,  
the apparatus comprising generating means for generating  
a value D representing the physical reaction caused by  
an event, and inferential processing means for deriving  
10 the marginal distributions of a probability distribution  
for the attribute or attributes  $\theta$  of the events by  
carrying out a Bayesian inferential process utilising the  
value D, the marginal values of a prior probability  
distribution and a stored set of values representing a  
15 range of probability distributions for the occurrence of  
each of the events being measured, the inferential  
process being an iterative process in which the marginals  
posterior to one event are generated by updating the  
marginals prior to that event.

20

2. Apparatus according to claim 1, wherein the  
generating means are adapted to generate an analog signal  
and include analog-to-digital conversion means for  
converting the analog signal into a digital signal and  
25 means for compressing the data content of the digital,  
the output of said compression means being connected to  
said processing means.

3. Apparatus according to claim 2, wherein the compression means are adapted to compress the digital output of the ADC means to generate the value D by taking quantized transformed log moments.

5

4. Apparatus according to claim 3, wherein the compression means obtain the quantized transformed log moments by carrying out the steps set out as follows:

10

$$\bar{y} = \frac{1}{M} \sum_{m=1}^M y_m$$

$$u_n = \frac{1}{M} \sum_{m=1}^M (y_m - \bar{y})^n$$

$$z_m = y_{m+1} - y_m$$

$$\bar{z} = \frac{1}{M-1} \sum_{m=1}^{M-1} z_m$$

15

$$u_n' = \frac{1}{M-1} \sum_{m=1}^{M-1} (z_m - \bar{z})^n$$

$$u = \begin{pmatrix} \log|u_2| \\ \log|u_3| \\ \log|u_2'| \end{pmatrix}$$

$$v = Tu + t$$

20 5. Apparatus according to any preceding claim, wherein the preset prior probability distribution is of Dirichlet form or is a mixture of Dirichlets.

6. Apparatus according to claim 5, wherein the preset prior probability distribution is

$$P(p | \sum_i p_i = 1) = \frac{\Gamma(\sum_i \alpha_i)}{\prod_i \Gamma(\alpha_i)} \prod_i p_i^{\alpha_i - 1}$$

5 where all  $\alpha_i > 0$ .

7. Apparatus according to any one of the preceding claims, wherein the marginals are updated using an algorithm carrying out the equation

10

$$\log P(p_i | D) = \log P(p_i) + \log(1 - p_i) + f \left( \log \frac{p_i}{1 - p_i} - \log \frac{P(E_i)}{1 - P(E_i)} + \log \left( \frac{P(D_{j_i} | E_i) P(E_i)}{\sum_{h \neq i} P(D_{j_h} | E_h) P(E_h)} \right) \right) + K$$

15 8. Apparatus according to any one of the preceding claims, wherein the generating means comprise a means defining a passage through which particles to be measured must pass, means for irradiating the particles, and means for detecting perturbations in the radiation caused by  
20 the particles to generate an analog signal.

9. Apparatus according to claim 8 wherein the means for irradiating the particles comprise a source of monochromatic light adapted to produce a structured light  
25 field in a measurement volume in said passage, particles in use passing transversely through the structured light field.

10. A method for obtaining measurements relating to an attribute or attributes  $\theta$  of a succession of events in which an event generates a measurable physical reaction, comprising generating a value  $D$  representing the physical  
5 reaction caused by an event, and using inferential processing means to derive the marginal distributions of a probability distribution for the attribute or attributes  $\theta$  of the events by carrying out a Bayesian inferential process utilising the value  $D$ , the marginal  
10 values of a prior probability distribution and a stored set of values representing a range of probability distributions for the occurrence of each of the events being measured, the inferential process being an iterative process in which the marginals posterior to one  
15 event are generated by updating the marginals prior to that event.

11. A method according to claim 10, wherein an analog signal is generated by the events being measured which  
20 signal is converted into a digital signal, and the digital signal is compressed prior to the inferential processing.

12. A method according to claim 11, wherein the digital  
25 signal is compressed by taking quantized transformed log moments.



13. A method according to any one of claims 10 to 12, wherein the preset prior probability distribution is of Dirichlet form or is a mixture of Dirichlets.